# PROCESS FOR BENDING WORKPIECES

The invention relates to a process for bending workpieces, particularly pipes, wires, bars, semi-finished products, sheet metal or the like, with at least one bending device.

In conventional processes for bending workpieces, a workpiece to be shaped is fed to a bending head of a bending machine by means of a feeding arrangement such as a cross slide, for example. The workpiece is picked up by a clamping device such as a collet chuck, for example, and is fed to the bending head by means of the cross slide. This process is disadvantageous because inserting the workpiece and arranging the workpiece on the bending device is time consuming.

Furthermore disadvantageous is that a conventional process for bending workpieces requires manual insertion into the bending device or bending machine. Removal and feeding of the workpieces to a final inspection is likewise primarily effected manually.

It is also known from the prior art that by means of a conventional robot, for example, workpieces can be loaded to a clamping device or collet chuck of a bending machine, said workpieces being subsequently completed in the bending machine. The scope of application of a bending machine is therefore limited.

Additionally, the workpieces must be bent or shaped in a bending machine. If other bending or shaping processes are necessary, the workpiece is fed to an additional

bending device for further machining. This permits no precise final inspection of the bending state in the process.

The object of the present invention is to provide a process for bending workpieces, particularly pipes, wires, bars, semi-finished products, sheet metal or the like, that overcomes said disadvantages and with which workpieces can be quickly and economically shaped or bent in one production step and optionally an optimized final inspection can occur directly after the bending.

This object is achieved in that at least one robot picks up the workpiece to be shaped and feeds it to the at least one bending device for shaping, in particular bending.

In the present invention, the workpiece being picked up and fed, by means of a robot, to a bending unit comprising at least one bending device has proven particularly advantageous. Once in the bending device, the workpiece is then shaped or bent under continuous or batch feed by means of the robot.

The workpiece is directly picked up by the robot or a gripping arm of a robot and is directly fed to a bending head of the bending device. If required, the robot can correspondingly radially rotate the workpiece with the corresponding gripping arm. It is thereby possible to dispense with a conventional clamping device or a conventional clamp feed device.

After the bending of a certain region, the workpiece can be picked up by means of the robot or its gripping arm conversely to, for example, directly re-clamp said workpiece in the bending device or its bending head so as to machine, for example, another end of the workpiece. This is not possible in the conventional process.

The workpiece is removed by means of the robot from a supply bin and fed to the bending unit or the at least one bending device for shaping or bending. After the bending, the bent workpiece can be conveyed to a storage area. The robot then grips a new workpiece that is to be shaped or bent from the supply bin and feeds it continuously or batch-wise again to the at least one bending device. The robot arm, particularly its gripping device, can take over the continuous feeding and radial rotating of the workpiece in the bending unit during the bending process.

Roller bending heads, right-hand/left-hand bending heads, and bending devices with mandrel devices, folding devices or the like that are stationarily arranged with respect to a background can be combined as bending devices.

However, as part of the present invention, the bending device is also intended to be moveable with respect to a background, in particular with respect to the robot. The at least one bending device can preferably be controlled manually and/or mechanically so as to move back and forth with respect to the robot on a cross slide, a track system, a linear system or the like.

A wide variety of workpieces of differing sizes or lengths can be machined in this manner with the present process. This would also make it possible for the robot to pick up very long pipes that could be bent in the bending device by the robot feeding the workpiece to be shaped directly to the bending heads of the bending device. This is likewise intended to be a part of the present invention.

A conveyor belt, a pick-up container, a machine such as a cutting unit or a transfer robot can serve as a supply bin that delivers or provides the workpiece to be shaped to the robot.

Subsequent to the shaping or bending of the workpiece, the robot then transfers the finished workpiece to a storage area, which can be a conveyor belt, a supply bin, a machine for additional processing, or a transfer robot, so as to feed the finished workpiece for a further processing step. The scope of the invention is not thereby limited.

In a further embodiment of the present invention, after the finishing of the workpiece the robot can feed the workpiece to a measuring device or guide the finished workpiece along the measuring device so that the complete contour of the finished workpiece can be recorded in three planes as a measured value and compared with a stored desired value. In this manner, a final inspection occurs automatically after the bending and shaping of the workpiece. If the workpiece does not correspond to the desired value or its tolerance range, re-bending can be effected by the robot feeding the workpiece anew to the bending unit for re-bending. Only subsequent to favorable re-inspection in the measuring device is the workpiece transferred to the storage area for further processing or machining.

The present invention is particularly advantageous in that a workpiece can very rapidly and fully-automatically be integrated in a production process by being removed from a supply bin, being shaped or bent in the bending unit or the at least one bending device, and, subsequent to successful intermediate inspection, by being optionally fed to a storage area. This enables the plant to save considerably on processing and manufacturing costs for the shaping and bending of workpieces.

Further advantages, features and details of the invention are evident from the following description of preferred embodiments as well as from the figures.

Figure 1 shows a schematic top view of a station for bending workpieces.

Figure 2 shows a schematic view of the station according to figure 1 as a further embodiment.

According to figure 1, a claimed station $R_1$ for bending arbitrary workpieces (1) comprises a supply bin (2) in which a plurality of workpieces (1) is stored. A conveyor belt can also be used as the supply bin (2) containing a plurality of workpieces that optionally may have been pre-worked.

The supply bin (2) can also be a robot or similar conveying equipment that provides to station $R_1$ the workpieces (1) to be shaped or bent.

It is significant in the present invention that the station $R_1$ is provided with at least one robot (3). The robot (3) comprises a robot arm (4) partitioned into a plurality of sections with a terminal gripping device (5). The robot (3) grips with the gripping device (5) the workpiece (1) to be shaped or bent and, after removing it from the supply bin (2), feeds it to the at least one bending device 6.

According to the requirement of the workpiece to be bent, a plurality of different types of bending heads (6) can be combined to form bending unit (7). The individual bending devices can, for example, be configured as roller bending heads, right-hand and/or left-hand bending heads, folding devices or the like so as to shape a workpiece in different ways.

It is important that in this process the feed is effected by the robot (3), in particular by the robot arm (4) and its terminally positioned gripping device (5), in the X-direction as indicated and that the rotating of the workpiece (1) about the workpiece axis is likewise effected in the Y-direction represented by the double arrow. The workpiece (1) is fed by means of the robot (3) to the at least one bending device (6) of the bending

unit (7) where it is bent and subsequently fed anew in the X-direction to the at least one bending device (6) so as to be bent anew. This results in the workpiece (1) being continuously advanced, by means of the robot (3), in the X-direction and/or radially rotated so that it can be shaped or bent in the Y-direction.

Preferably the robot only undertakes both the advancing function in the X-direction and the radial rotation of the workpiece (1) in the indicated Y-direction. In this manner, a workpiece (1) can be shaped, in particular bent, in three planes.

Optionally, during the bending process or while the workpiece (1) is clamped in the bending device (6), the robot (3) or its gripping device (5) can pick up the workpiece (1) again at a different place in order to continue the bending process as described above.

After bending, the finished workpiece (1) is delivered by means of the robot (3) to a storage area (8) where it is stored. A conveyor belt, a transfer robot, a supply bin or the like can serve as said storage area (8). The scope of the invention is not thereby limited.

In an embodiment of the present invention according to figure 2, a station $R_2$ is described that approximately corresponds to station $R_1$, the difference being that in the former, a measuring device (9) is interposed between the bending unit (7) and the storage area (8). Subsequent to shaping or bending, the finished bent or shaped workpiece (1) is removed from the bending unit (7) by means of the robot (3) and is guided along the measuring device (9), the bent contour of the workpiece (1) being moved over the measuring device (9). An intended state of the bent workpiece (1) is determined and compared with a stored measured value and/or tolerance zone. Should the measured value deviate impermissibly from the intended value, the workpiece (1) can be re-fed, by means of the robot (3), to the bending unit (7) for re-bending and adjustment bending.

The bent or shaped workpiece (1) is then re-inspected in the measuring device (9). Only after the desired value and measured value agree is the bent or shaped workpiece (1) fed or transferred to the storage area (8).

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